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INTERNET MESSAGE PROTOCOL

Jonathan B. Postel

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Information Sciences Institute
University of Southern California
4676 Admiralty Way
Marina del Rey, California 90291

(213) 822-1511

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Postel

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PREFACE

This is the first edition of this specification and should be treated as a request for comments, advice, and suggestions. A great deal of prior work has been done on computer aided message systems and some of this is listed in the reference section. This specification was shaped by many discusions with members of the ARPA research community, and others interested in the development of computer aided message systems. This document was prepared as part of the ARPA sponsored Internetwork Concepts Research Project at ISI, with the assistance of Greg Finn, Alan Katz, Paul Mockapetris, and Mamie Chew.

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J. Postel
USC-ISI
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1. INTRODUCTION

This document describes an internetwork message system. The system is designed to transmit messages between message processing modules according to formats and procedures specified in this document. The message processing modules are processes in host computers. Message processing modules are located in different networks and together constitute an internetwork message delivery system.

This document is intended to provide all the information necessary to implement a compatible cooperating module of this internetwork message system.

1.1. Motivation

As computer supported message processing activities grow on individual host computers and in networks of computers, there is a natural desire to provide for the interconnection and interworking of such systems. This specification describes the formats and procedures of a general purpose internetwork message system, which can be used as a standard for the interconnection of individual message systems, or as a message system in its own right.

We also provide for the communication of data items beyond the scope of contemporary message systems. Messages can include typed segments which could represent drawings, or facsimile images, or digitized speech. One can imagine message stations equipped with speakers and microphones (or telephone hand sets) where the body of a message or a portion of it is recorded digitized speech. The output terminal could include a graphics display, and the message might present a drawing on the display, and verbally (via the speaker) describe certain features of the drawing. This specification provides basic data elements for the transmission of structured binary data, as well as providing for text transmission.

1.2. Scope

The Internet Message Protocol is intended to be used for the transmission of messages between networks. It may also be used for the local message system of a network or host. This specification was developed in the context of the ARPA work on the interconnection of networks, but it is anticipated that it has a more general scope.

The focus here is on the internal mechanisms to transmit messages, rather than the external interface to users. It is assumed that a number of user interface programs will exist. These will be both new programs designed to work with system and old programs designed to work with earlier systems.

1.3. The Internetwork Environment

The internetwork message environment consists of processes which run in hosts which are connected to networks which are interconnected by gateways. Each individual network consists of many different hosts. The networks are tied together through gateways. The gateways are essentially hosts on two (or more) networks and are not assumed to have much storage capacity or to "know" which hosts are on the networks to which they are attached [5].

1.4. Operation

The model of operation is that this protocol is implemented in a process. Such a process is called a Message Processing Module or MPM. The MPMs exchange messages by establishing full duplex communication and sending the messages in a fixed format described in this document. The MPM may also communicate other information by means of commands described here.

A message is formed by a user interacting with a User Interface Program or UIP. The user may utilize several commands to create various fields of the message and may invoke an editor program to correct or format some or all of the message. Once the user is satisfied with the messages it is "sent" by placing it in a data structure shared with the MPM.

The MPM discovers the unprocessed input data (either by a specific request or by a general background search), examines it, and using routing tables determines which outgoing link to use. The destination may be another user on this host, a user on another host in this network, or a user in another network.

In the first case, another user on this host, the MPM places the message in a data structure shared with the destination user, where that user's UIP will look for incoming messages.

In the second case, the user on another host in this network, the MPM transmits the message to the MPM on that host. That MPM then repeats the routing decision, and discovering the destination is local to it, places the messages in the data structure shared with the destination user.

In the third case, the user on a host in another network, the MPM transmits the messages to an MPM in that network if it knows how to establish a connection directly to it, otherwise the MPM transmits the message to an MPM that is "closer" to the destination. An MPM might not know of direct connections to MPMs in all other networks, but it must be able to select a next MPM to handle the message for each possible destination network.

A MPM might know a way to establish direct connections to each of a few MPMs in other nearby networks, and send all other messages to a particular big brother MPM that has a wider knowledge of the internet environment.

A individual network's message system may be quite different from the internet message system. In this case, intranet messages will be delivered using the network's own message system. If a message is addressed outside the network, it is given to a MPM which then sends it through the appropriate gateways via internet procedures and format to (or toward) the MPM in the destination network. Eventually, the message gets to a MPM on the network of the recipient of the message. The message is then sent via the local message system to that host.

When local message protocols are used, special conversion programs are required to transform local messages to internet format when they are going out, and to transform internet messages to local format when they come into the local environment. Such transformations are potentially information lossy. The internet message format attempts to provide features to capture all the information any local message system might use. However, a particular local message system is unlikely to have features equivalent to all the possible features of the internet message system. Thus, in some cases the transformation of an internet message to a local message discard of some of the information. For example, if an internet message carrying mixed text and speech data in the body is to be delivered in a local system which only carries text, the speech data may be replaced by the text string "There was some speech here". Such discarding of information is to be avoided when at all possible, and to be defered as long as possible, still the possibility remains, that in some cases, it is the only reasonable thing to do.

1.5. Interfaces

The MPM calls on a reliable communication procedure to communicate with other MPMs. This is a Transport Level protocol such as the TCP [20]. The interface to such a procedure conventionally provides calls to open and close connections, send and receive data on a connection, and some means to signal and be notified of special conditions (i.e., interrupts).

Internet Message Protocol
Introduction

The MPM receives input and produces output through data structures that are produced and consumed respectively by user interface (or other) programs.

2. FUNCTIONAL DESCRIPTION

2.1. Terminology

The basic unit transferred between networks is called a message. A message is made up of a transaction identifier (a number which uniquely identifies the message), a command list (which contains the necessary information for delivery), and the document list. The document list consists of a header and a body, which contains the actual data of the message.

For a personal letter the document body corresponds to the contents the a letter, the document header corresponds to the the address and return address on the envelope.

For an inter-office memo the document body corresponds to the text, the document header corresponds to the header of the memo.

The commands correspond to the information used by the Post Office or the mail room to route the letter or memo.

The messages are routed by a process called the message processing module or MPM. Messages are created and consumed by User Interface Programs (UIPs) in conjunction with users.

Please see the Glossary section for a more complete list of terminology.

2.2. Assumptions

The following assumptions are made about the internetwork environment:

It is in general not known what format intranet addresses will assume. Since no standard addressing scheme would suit all networks, it is safe to assume there will be several and that they will change with time. Thus, frequent software modification throughout all internet MPMs would be required if such MPMs were to know about the formats on many networks. Therefore, each MPM which handles internet messages is required to know only the minimum necessary to deliver them.

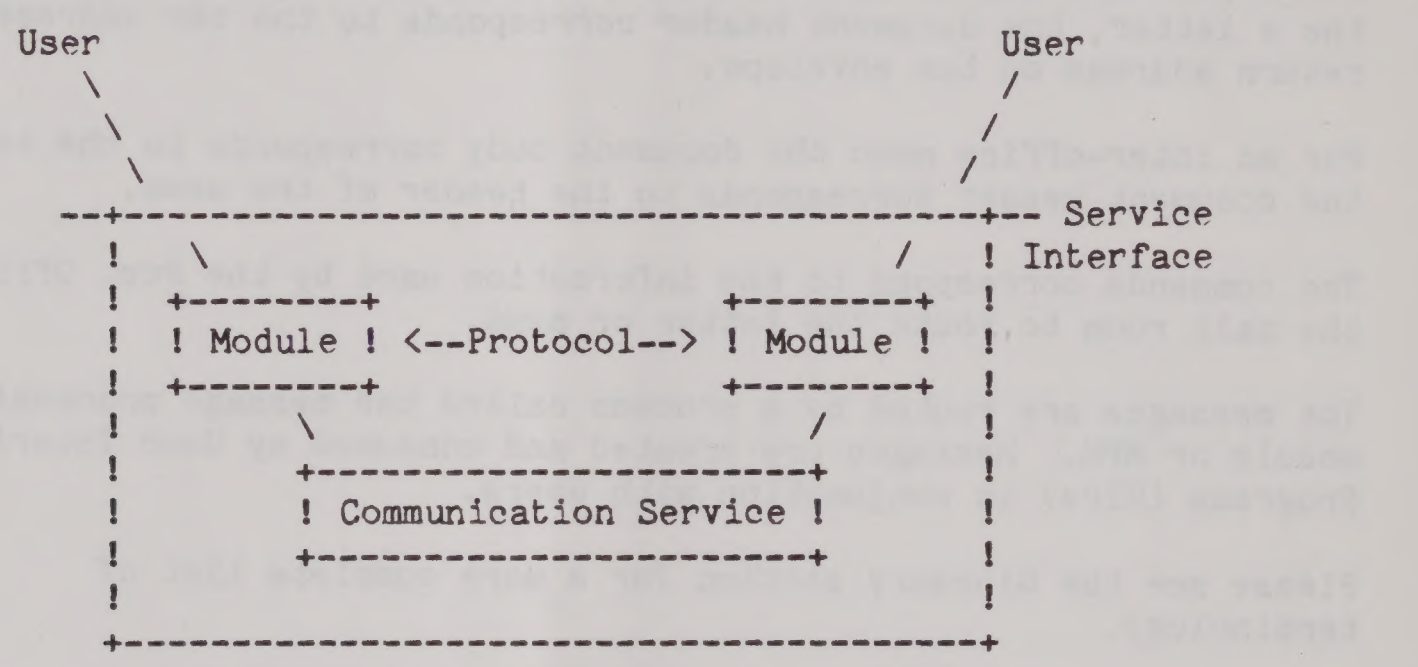
We require each MPM to know completely only the addressing format of its own network. In addition, the MPM must be able to select an output link for each message addressed to another network or host. This does not preclude more intelligent behavior on the part of a given MPM, but at least this minimum is necessary. Each network has a unique name and number.

Each MPM will have a unique internet address. This feature will

enable every MPM to place a unique "handling-stamp" on a message which passes through it en-route to delivery.

2.3. General Specification

There are several aspects to a distributed service to be specified. First there is the service to be provided, that is, the characteristics of the service as seen by its users. Second there is the service it uses, that is, the characteristics it assumes to be provided by some lower level service. And, third there is the protocol used between the modules of the distributed service.



Message Service

Figure 1.

The User/Message Service Interface

The service the message delivery system provides is to accept messages conforming to a specified format and to attempt to deliver those messages, and to report on the success or failure of the delivery attempt. This service is provided in the context of an interconnected system of networks, and may involve relaying a message through several intermediate MPMs utilizing different communication services.

The Message/Communication Service Interface

The message delivery system calls on a communication service to transfer information from one MPM to another. There may be different communication services used between different pairs of

MPMs, though all communication services must meet the following service characteristics.

It is assumed that the communication service provides a reliable two way data stream. Such a data stream can usually be obtained in computer networks from the transport level protocol, for example, the Transmission Control Protocol (TCP) [20]. In any case the properties the communication service must provide are:

- o Logical connections for two way simultaneous data flow of arbitrary data (i.e., no forbidden codes). Data is delivered in the order sent with no gaps.

- o Simple commands to open and close the connections, and to send and receive data on the connections.

- o A way to signal and be notified "out-of-band" (such as TCP's urgent) is available so that some messages can be labeled "more important" than others.

- o Controlled flow of data so that data is not transmitted faster that the receiver chooses to consume it (on the average).

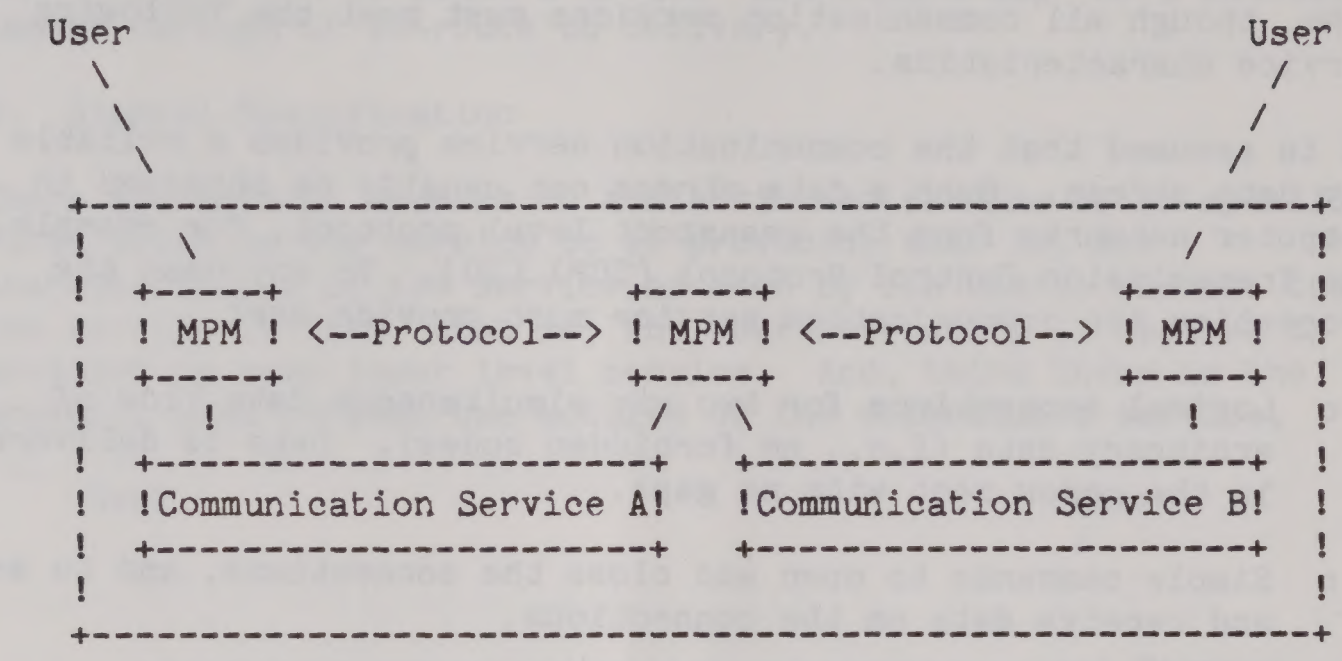
- o Transmission errors are corrected without user notification or involvement. Complete breakdown on communication is reported to the user.

The Message-Message Protocol

The protocol used between the distributed modules of the message delivery system, that is, the MPMs is a small set of commands which convey requests and replies. These commands are encoded in a highly structured and rigidly specified format.

2.4. Mechanisms

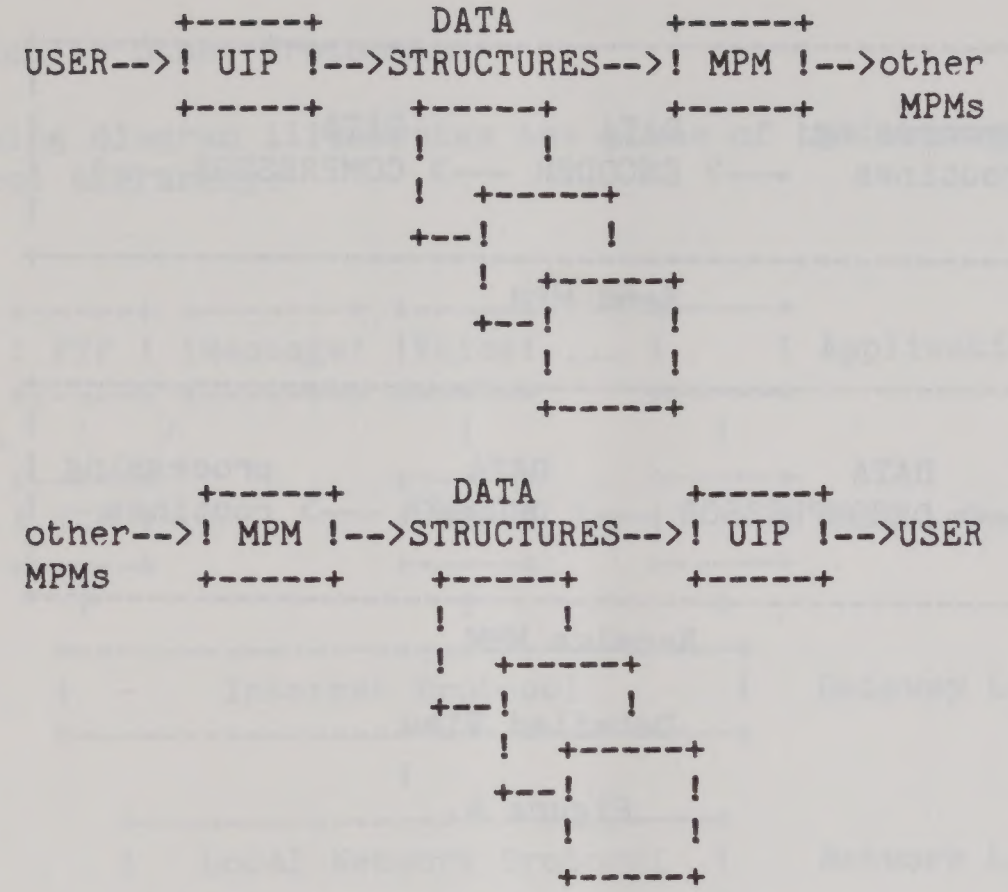
MPMs are processes which use some communication service. A pair of MPMs which can communicate reside in a common interprocess communication environment. A MPM might exist in two (or more) interprocess communication environments, and such an MPM might act to relay messages between MPMs in the environments.



Message Service with Internal Relaying

Figure 2.

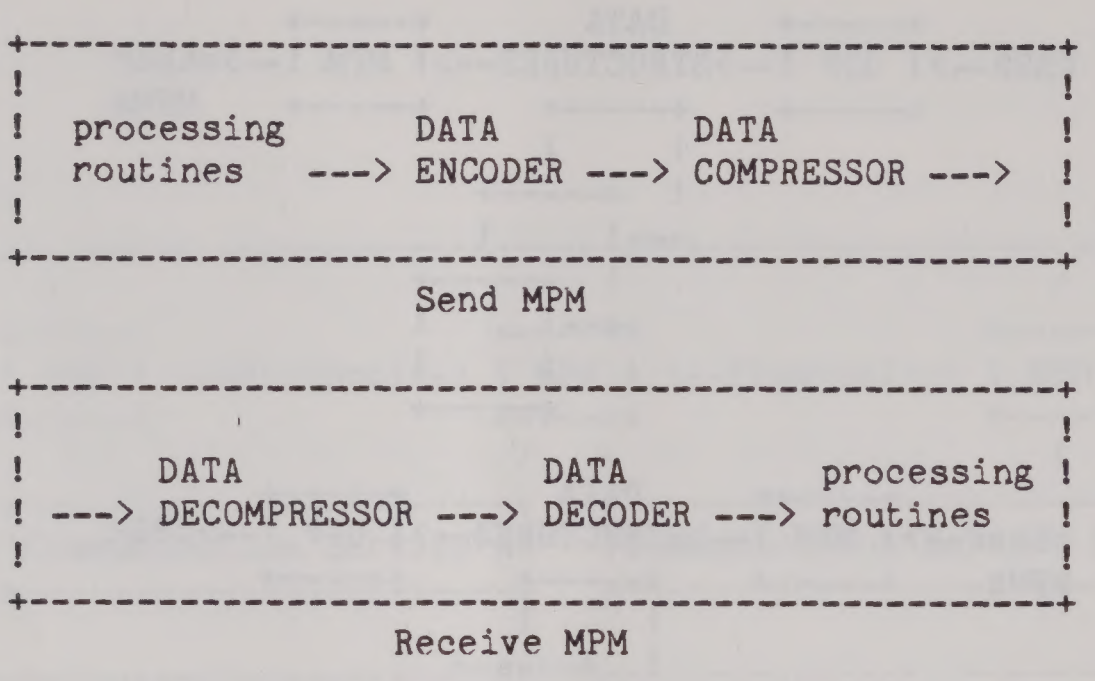
The transfer of data between UIPs and MPMs is conceived of as the exchange of data structures which encode messages. The transfer of data between MPMs is also in terms of the transmission of structured data.



Message Flow

Figure 3.

In the following, a message will be described as a structured data object represented in a particular kind of typed data elements. This is how a message is presented when transmitted between MPMs or exchanged between an MPM and a UIP. Internal to a MPM (or a UIP), a message may be represented in any convenient form. As the following figure shows, when a message is ready for transmission, it moves from the processing routines to be encoded in the typed data elements and then to a data compression routine, and is finally transmitted. On the receiving side, the message is first decompressed then decoded from the data element representation to the local representation for the processing routines.

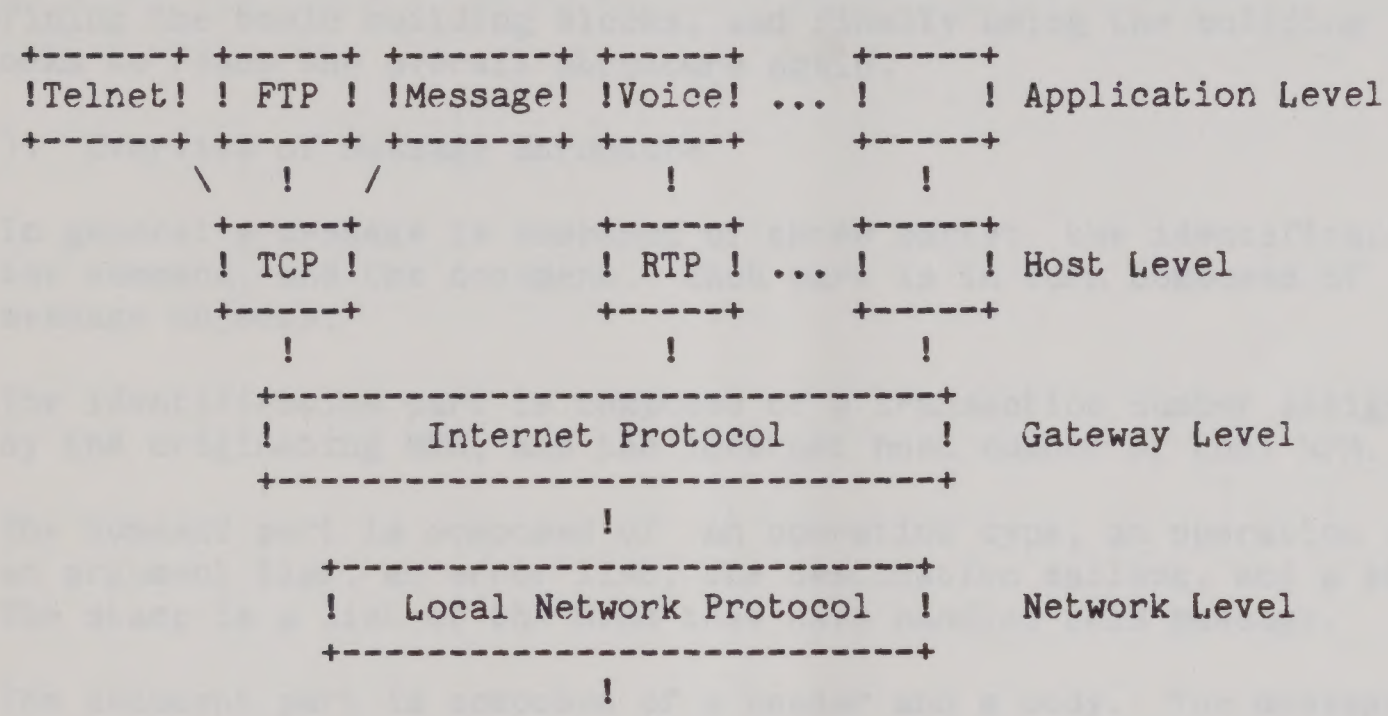


Detailed View

Figure 4.

2.5. Relation to Other Protocols

The following diagram illustrates the place of the message protocol in the protocol hierarchy:



Protocol Relationships

Figure 5.

The message protocol interfaces on one side to user interface programs and on the other side to a reliable transport protocol such as TCP.

3. DETAILED SPECIFICATION

The presentation of the information in this section is difficult since everything depends on everything, and since this is a linear media it has to come in some order. In this attempt, a very brief overview of the message structure is given, then a radical switch is made to defining the basic building blocks, and finally using the building blocks to reach the overall structure again.

3.1. Overview of Message Structure

In general a message is composed of three parts: the identification, the command, and the document. Each part is in turn composed of message objects.

The identification part is composed of a transaction number assigned by the originating MPM, and the internet host number of that MPM.

The command part is composed of an operation type, an operation code, an argument list, an error list, the destination mailbox, and a stamp. The stamp is a list of the MPMs that have handled this message.

The document part is composed of a header and a body. The message delivery system does not depend on the contents of the document part, but this specification does make some recommendations for the document header.

The following sections define the representation of a message as a structured object composed of other objects. Objects in turn are represented using a set of basic data elements.

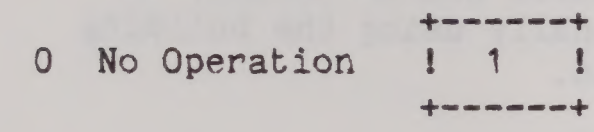
3.2. Data Elements

The data elements defined here are similar to the data structure and encoding used in NSW [18].

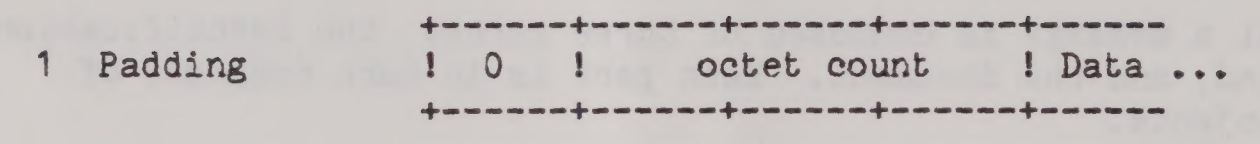
Each of the diagrams which follow represent a sequence of octets. Field boundaries are denoted by the "!" character, octet boundaries by the "+" character. The diagrams are presented in left to right order. Each element begins with a one octet code.

Code	Type	Representation

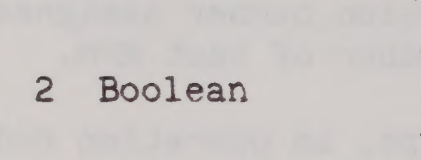
0 No Operation



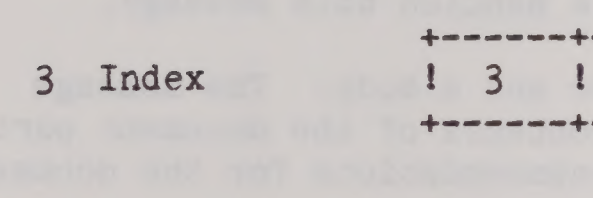
1 Padding



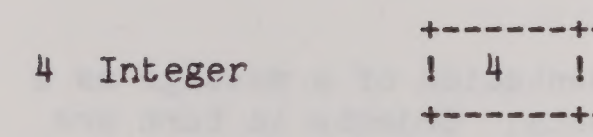
2 Boolean



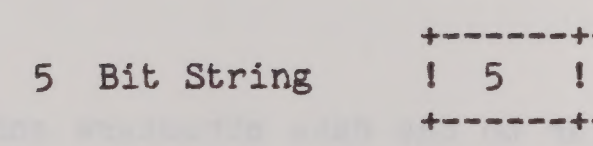
3 Index



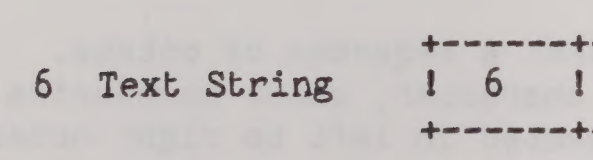
4 Integer



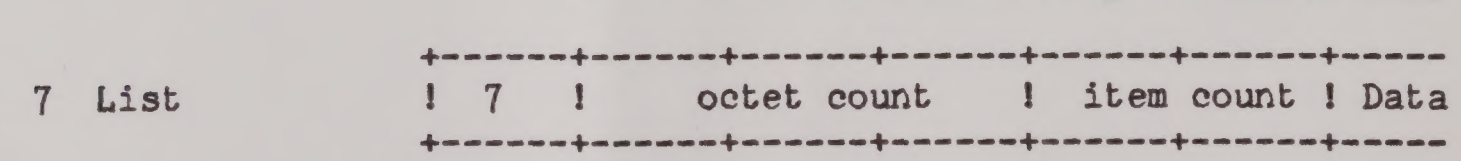
5 Bit String



6 Text String



7 List



8 Proplist

Element code 0 (NOP) is an empty data element used for padding when it is necessary. It is ignored.

Element code 1 (PAD) is used to transmit large amounts of data with a message for test or padding purposes. No action is taken with this data but the count of dummy octets must be correct to indicate the next element code.

Element code 2 (BOOLEAN) is a boolean data element which has the value 1 for True and 0 for False.

Element code 3 (INDEX) is a 16-bit unsigned integer datum. Element code 3 occupies only 3 octets.

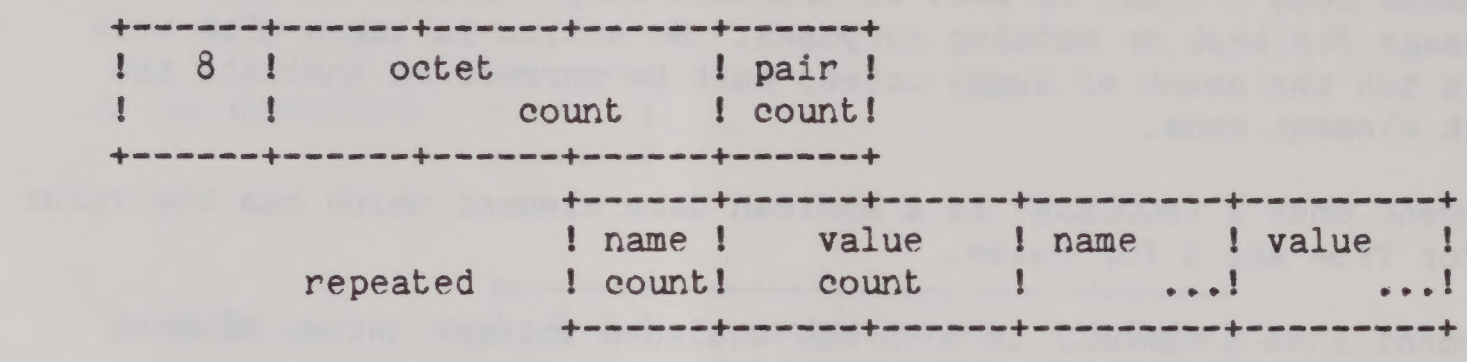
Element code 4 (INTEGER) is a signed 32-bit integer datum. This will always occupy five octets. Representation is two's complement.

Element code 5 (BITSTR) is a bit string element for binary data. The bit string is padded on the right with zeros to fill out the last octet if the bit string does not end on an octet boundary. This data type must have the bit-count in the two octet count field instead of the number of octets.

Element code 6 (TEXT) is used for the representation of text. Seven bit ASCII characters are used, right justified in the octet. The high order bit in the octet is zero.

Element code 7 (LIST) can be used to create structures composed of other elements. The item-count contains the number of elements which follow. Any element may be used including List itself. The octet count specifies the number of octets in the whole list. A null or empty List, one with no elements, has an item-count of zero (0).

Element code 8 (PROPLIST) is the Property-List element. It has the following form:



The Property-List structure consists of a set of unordered name/value pairs. The pairs are a one octet name count and a two octet value count followed by the name and value strings. The counts specify the length in octets of the name and value strings. Each string has a length in octets which agrees with its respective count. The count of octets until the next pair in the property list is 1 + 2 + name count + value count octets. The entire Property-List is of course equal in length to the octet count of the element itself. Immediately following the octet count for the entire element is a one octet pair count field which contains the total number of name/value pairs in the Proplist.

3.3. Message Objects

In the composition of messages we use a set of objects such as address, or date. These objects are encoded in the basic data elements. The message objects are built of data elements.

While data elements are typed, message objects are not. This is because messages are structured to the extent that only one kind of message object may occur in any position of a message structure.

The following is a list of some of the objects used in messages. The object descriptions are grouped by the section of the message in which they normally occur.

Identification

Internet Host Number (ihn)

This identifies a host in the internetwork environment. When used as a part of tid, it identifies the originating host of a message. The ihn is a 32 bit number, the higher order 8 bits identify the network, and the lower order 24 bits identify the host on that network.

INTEGER

Transaction Identifier (tid)

This is the transaction identifier associated with a particular command. It is a list of the transaction number and the internet host number of the originating host.

LIST (tn , ihn)

Transaction Number (tn)

This is a number which is uniquely associated with this transaction by the originating host. It identifies the transaction. (A transaction is a message and acknowledgment, this is discussed in more detail in later sections.) A tn must be unique for the time which the message (a request or reply) containing it could be active in the network.

INDEX

Command

Address

This is very similar to Mailbox in that it also is the "address" of a user. However, Address is intended to contain the minimum information necessary for delivery, and no more.

PROPLIST (---)

Answer

A yes (true) or no (false) answer to a question.

BOOLEAN

Arguments

This is the argument to many of the operations. It consists of a List of different data types. The List will have form and data relevant with the particular operation.

LIST (---)

Command-Type

Gives the type of a command (e.g., request, reply, alarm).

INDEX

Error-List

The error list contains information concerning an error which has occured. It is a List comprised of the two objects error-class and error-string.

LIST (error class, error string)

Error-Class

A code for the class of the error.

INDEX

Error-String

A text string explaining the error.

TEXT

How-Delivered

A comment on the delivery of a messages, for instance a message could be delivered, forwarded, or turned over to general delivery.

LIST (TEXT)

Mailbox

This is the "address" of a user of the internetwork mail system. Mailbox contains information such as net, host, location, and local user-id of the recipient of the message. Some information contained in Mailbox may not be necessary for delivery.

As an example, when one sends a message to someone for the first time, he may include many items which are not necessary simply to insure delivery. However, once he gets a reply to this message, the reply could contain an Address (as opposed to Mailbox) which the user will use from then on.

A mailbox is a PROPLIST. A mailbox might contain the following name-value pairs:

name	element	description
IA	INTEGER	internet address
NET	TEXT	network name
HOST	TEXT	host name
USER	TEXT	user name
CITY	TEXT	city
COUNTRY	TEXT	country
STATE	TEXT	state
ZIP	TEXT	zip code
PHONE	TEXT	phone number

PROPLIST (---)

Operation

This names the operation or procedure to be performed.

TEXT

Options

REGULAR for normal delivery, FORWARD for message forwarding, GENDEL for general delivery, or other options which may be defined later.

LIST (TEXT, ...)

Reasons

These could be mailbox does not exist, mailbox full, etc.

LIST (TEXT)

Stamp

Each MPM that handles the message must add a unique identifier (ihn, see above) to the list. This will prevent messages from being sent back and forth through the internet mail system without eventually either being delivered or returned to the sender.

LIST (ihn, ihn, ...)

Trail

When a message is sent through the internetwork environment, it acquires a list of MPMs that have handled the message in "Stamp". This list is then carried as "Trail" upon reply or acknowledgment of that message. More simply, requests and replies always have a "Stamp" and each MPM adds its ihn to this "Stamp." Replies, in addition, have a "Trail" which is the complete "Stamp" of the original message.

LIST (ihn, ihn, ...)

Type

The command type, e.g., request or reply.

INDEX

Document

In this section, we define some objects useful in message document headers. The ones we use are taken from the current ARPANET message syntax standard [6,8].

CC

When copies of a message are sent to others in addition to the addresses in the To object, those to whom the copies are sent will have their addresses recorded here. CC will be a single TEXT element.

TEXT

Date

The date and time are represented according to the International Standards Organization (ISO) recommendations [13,14,15]. Taken together the ISO recommendations 2014, 3307, and 4031 result in the following representation of the date and time:

yyyy-mm-dd-hh:mm:ss,fff+hh:mm

Where yyyy is the 4 digit year, mm is the two digit month, dd is the two digit day, hh is the two digit hour in 24 hour time, mm is the two digit minute, ss is the two digit second, and fff is the decimal fraction of the second. To this basic date and time is appended the offset from Greenwich as plus or minus hh hours and mm minutes.

TEXT

Document-Body

The document body will contain that portion of the message commonly thought of as the text portion. It will be composed of a list of elements. This will allow transmission of data other than pure text if such capabilities are needed. We can, for instance, envision digital voice communication through the transmission of BITSTR element, or transmission of graphic data, etc. Information regarding control of such features could be included in the header for cooperating sites, or in the body itself but such protocols would depend upon agreement among those sites involved. It is expected of course that the majority of messages will contain body portions comprised of TEXT elements.

LIST (---)

Document-Header

The document header contains the memo header presented to the user. In principle this may be of any style or structure. In this specification it is recommended that a PROPLIST be used and that the name-value pairs correspond to the header fields of RFC 733 [6].

PROPLIST (---)

From

The From is meant to be the name of the author of a document. It will be one TEXT element.

TEXT

Reply-To

Sometimes it will be desired to direct the replies of a message to some address other than the From or the Sender. In such a case the Reply-To object can be used.

TEXT

Sender

The Sender will contain the address of the individual who sent the message. In some cases this is NOT the same as the author of the message. Under such a condition, the author should be specified in the From object. The Sender is a single TEXT element.

TEXT

Subject

The subject of the message.

TEXT

To

To identifies the addressees of the message. The To object is one TEXT element.

TEXT

3.4. Command

This section describes the commands which processes in the internet message system can use to communicate. Several aspects of the command structure are based on the NSW Transaction Protocol [19]. The commands come in pairs, with each request having a corresponding reply.

A command is a list:

LIST (mailbox, stamp, type, operation, arguments, error-list)

The arguments are described generally here and more specifically, if necessary, in the description of each command.

mailbox: PROPLIST

This is the "to" specification of the message. Mailbox takes the form of a property list of general information, some of which is the essential information for delivery, and some of which could be extra information which may be helpful for delivery. Mailbox is different from address in that address is a very specific list without extra information.

stamp: LIST (INTEGER, ...)

This is a list of the MPMs that have handled the message. Each MPM must add its 32 bit Internet Host Number (ihn) to the LIST.

type: INDEX

type=1 a REQUEST operation.

type=2 a REPLY operation.

type=3 an ALARM operation. (A high priority message.)

type=4 a RESPONSE to an alarm operation.

operation: TEXT

Operation is the name of the operation or procedure to be performed. This string must be interpreted in an upper/lower case independent manner.

arguments: LIST

This is a list of arguments to the above operation.

error-list: LIST

If message is type 1 or 3 (a request or an alarm):

LIST ( ) (a zero length list)

If message is a type 2 or 4 (a response or response to alarm)

LIST (error-class, error-string) indicates what,if any, error occured

error-class: INDEX

=0: indicates success, no error
=1: partial results returned.
This error class is used when several steps are performed by one operation and some of them fail.
=2: failure, resources unavailable.
=3: failure, user error.
=4: failure, MPM error. Recoverable.
=5: failure, MPM error. Fatal.
=6: User abort requested

error-string: TEXT

This is a human readable character string describing the error.

Possible errors:

error-string	error-class
No errors	0
Command not implemented	2
Syntax error, command unrecognized	3
Syntax error, in arguments	3
Server error, try again later	4
No service available	5
User requested abort	6

```
command:  DELIVER

  type:  1

  function:  Sends message to a mailbox

  reply:  The reply is ACKNOWLEDGE

  arguments:  LIST ( options )

    options:  one or more of the following

      "REGULAR"  regular delivery

      "FORWARD"  message forwarding

      "GENDEL"   general delivery

      other options which may be defined later

  argument structure:

    LIST ( LIST ( TEXT, ... ))
```

command: ACKNOWLEDGE

type: 2

function: reply to DELIVER

arguments: LIST (tid, trail, answer, reasons, how-delivered)

tid: tid of the originating message

trail: the stamp from the deliver command

answer: yes if delivered successfully,
no if error in delivery.

reasons: if the answer is yes, the reason is "ok", if the answer is no the reason could be one of "no such user", "no such host", "no such network", "address ambiguous", or a similar response

how-delivered: one or more of the following:

"FORWARD" message was accepted for forwarding

"GENDEL" message was accepted for general delivery

"ACCEPT" message was accepted for normal delivery

other types of delivery may be defined later

argument structure:

```
LIST ( LIST ( INDEX, INTEGER ),
       LIST ( INTEGER, ... ),
       BOOLEAN,
       LIST ( TEXT ),
       LIST ( TEXT ))
```

command: PROBE

type: 1

function: finds out if specified mailbox (specified in mailbox of the command) exists at a host

reply: the reply is RESPONSE

arguments: LIST (--none--)

argument structure:

LIST ( )

command: RESPONSE

type: 2

function: reply to PROBE

arguments: LIST (tid, trail, answer, address OR reasons)

tid: the tid which came from the originating PROBE

trail: the stamp which came from the originating PROBE

answer: Yes if mailbox found, or no for invalid mailbox

if answer is yes the fourth argument is address
if answer is no it is reasons

address: a specific address in the network

reasons: a reason why mailbox is invalid

Possible reasons include:

"Mailbox doesn't exist"

"Mailbox full"

"Mailbox has moved, try this new location", address

address is a new address to try

argument structure:

if answer is yes

```
LIST ( LIST ( INDEX, INTEGER ),
       LIST ( INTEGER, ... ),
       BOOLEAN,
       PROPLIST )
```

if answer is no

```
LIST ( LIST ( INDEX, INTEGER ),
       LIST ( INTEGER, ... ),
       BOOLEAN,
       LIST ( TEXT ))
```

command: CANCEL

type: 3

function: abort request for specified transaction

reply: The reply is CANCELED

arguments: LIST (tid)

tid of transaction to be cancelled

argument structure:

LIST (LIST (INDEX, INTEGER))

command: CANCELED

type: 4

function: reply to CANCEL

arguments: LIST (tid, trail, answer)

tid: tid of transaction to be cancelled

trail: the stamp of the CANCEL command

answer: yes if the command was canceled, no if not.

argument structure:

```
LIST ( LIST ( INDEX, INTEGER ),
       LIST ( INTEGER, ... ),
       BOOLEAN )
```

To summarize again, a command consists of a LIST of the following objects:

name	element
mailbox	PROPLIST
stamp	LIST (INTEGER, ...)
type	INDEX
operation	TEXT
arguments	LIST (---)
error	LIST (INDEX, TEXT)

3.5. Document

The actual document follows the command list. It contains a header which usually contains such information as From, To, Date, CC, etc.; and the actual body of the message. The message delivery system does not depend on the document. The following section should be taken as a recommendation for common practice, not as a requirement.

Document Header

For the same reason that it is impossible to for see the many forms that intranet addresses will take, standardizing of document headers would also be a mistake. The approach we suggest is to lay the groundwork for a set of basic document header functions and provide for enough extensibility to allow nets to add whatever header features they desire. Features added in this fashion, however, may not be understood by other networks. It is suggested that subset defined here be implemented by all networks.

This subset is taken from the current ARPANET standard for message headers in the text oriented computer message system [6,8].

The document header will precede the document body portion of the message and will consist of a proplist data element. The document header is meant to be used by individual networks to tailor the header to suit their individual needs. As an example, consider the ARPA network. Typically, the receiver's name is taken to be his network address. It often prints in the document header in just that form: Frank@SITEX. Such a salutation is unacceptable in some more formal modes of communication. Some network might choose to place into header proplist the name-value pair ("SALUTATION:", "Mr. Frank Hacker"). Upon receipt of the message, the document handling program would then be able to scan the header proplist looking for such a pair and so be able to correctly address the recipient by name instead of by network address. However, other networks or

sites within the network may not understand such specific information. Under such a condition it should be ignored.

The minimum header is a PROPLIST of the following name-value pairs:

Name	Value
DATE	TEXT
FROM	TEXT

A normal header is a PROPLIST containing the following name-value pairs:

Name	Value
DATE	TEXT
SENDER	TEXT
FROM	TEXT
TO	TEXT
CC	TEXT
SUBJECT	TEXT

Document Body

The Body of the message is just a sequence of data elements which contains the actual document. Much of the time this will be a single TEXT element, but for some applications other data elements may be utilized.

LIST (---)

3.6. Message Structure

An internet message is composed of three parts. The first is the tid which identifies the transaction; the second is the Command List; and the third part is the Document List, which is itself comprised of a Document-Header and a Document-Body.

When shipped between two MPMs, a message will take the form of a LIST:

Message is:

LIST (tid, Command-List, Document-List)

It is convenient to batch several messages together shipping them as a unit from one MPM to another. Such a group of messages is called a message-bag.

A message-bag will be a LIST of Messages, each Message is of the form described above.

Thus, a message-bag is:

LIST (Message1, Message2, ...)

Message Sharing

When messages are batched for delivery, it may often be the case that the same Document will be sent to more than one recipient. Since the Document portion can usually be expected to be the major parts of the message, much repeated data would be sent if a copy of the Mail for each recipient were to be shipped in the message-bag.

To avoid this redundancy, messages are assembled in the message-bag so that actual data appears first and references to it appear later in the message-bag. Since each message has a unique tid, the references will indicate the tid of the actual data. In this sense, all references to copied data may be thought of as pointing earlier in the message-bag. The data to be retrieved can be thought of as indexed by tid. Note that the semantics require such references to point to data already seen.

When a portion is Shared, that portion is determined by its position within a message, i.e., if the Command list was to be Shared, then its position within a Message would contain the tid of the message already seen whose Command list was identical to it. The same is true of the Document Header and the Document Body. Only a complete Command, Header, or Body may be Shared, never a partial one.

If an encryption scheme is used, that portion of the message which is encrypted can not be shared. This is due to the fact that encrypting keys will be specific between two individuals.

Internal Message Organization

The tid

Tnis is the transaction identifier. It is assigned by the originating MPM.

The Command List

The command-list is a LIST which contains two elements, content and command.

Content is one item of element type INDEX. If content=0, the item is not shared and the next element of the LIST is the command. If content=1 the item is shared. In this case, the second element will contain the tid of the command to share from. The tid must be of a prior message in the current message-bag. Other values of content may be defined later for different data structures.

Thus, command-list is:

```
LIST ( content, tid )        if content=1
```

Or,

```
LIST ( content, command )    if content=0
```

content is:

```
INDEX     which is 0 if there is no sharing
            and is 1 if sharing occurs
```

tid is:

```
the tid of the message to be shared from
```

command is:

```
LIST ( mailbox, stamp, type, operation, arguments, error-list )
```

The document-list

The document portion of an internet message is optional and when present is comprised of a LIST containing two elements:

document-list is:

LIST (header-list, body-list)

While either the header-list or the body-list may be shared, both elements must appear in the m.

The document-header

The header-list will be a List which will always contain two elements. The first element will be content to indicate whether or not the header is to be shared. The second element will either be the tid of the header to be copied (if content=1) or it will be the document-header (which is a PROPLIST) containing the actual header information (if content=0). The tid must point to a document-header already seen in the message-bag.

The header-list is either:

LIST (content, tid) if content=1

Or,

LIST (content, document-header) if content=0

document-header is:

PROPLIST which contains header information

The document-body

The body-list will be a LIST of two elements. The first element will again be content, indicating whether or not the body is to be shared. If it is shared, the second element will be tid indicating which body to copy. This tid must be of a message already seen in the message-bag. If content indicates no sharing, then the second item is a document-body.

body-list is:

LIST (content, tid) if content=1

Or,

LIST (content, document-body) if content=0

document-body is:

LIST (items comprising the body ...)

Message Fields

message := (tid, command-list, document-list)

tid := (tn, ihn)

command-list := (content, command)

command := (mailbox, stamp, type, operation,
arguments, error-list)

document-list := (header-list, body-list)

header-list := (content, document-header)

body-list := (content, document-body)

3.7. MPM Organization

Introduction

The heart of the internet message system is the MPM which is responsible for routing and delivering message between the networks. Each network must have at least one MPM. These MPMs are connected together, and internet mail is always transferred along channels between them. The system interfaces with the already existent local message system.

Since the local network message system may be very different from the internet system, special programs may be necessary to convert incoming internet messages to the local format. Likewise, messages outgoing to other networks may be converted to the internet format.

The MPM

Messages in the internet mail system are shipped in "bags," each bag containing one or more messages. Each bag is addressed to a specific MPM and contains messages for the hosts on that MPM's network.

Each MPM is expected to implement functions which will allow it to deliver local messages it receives and to forward non-local ones to other MPMs presumably closer to the message's destination.

Loosely, each MPM can be separated into five components:

1--Acceptor

Receives incoming Message-Bags, from other MPMs, from UIPs, or from conversion programs.

2--Message-Bag Processor

Splits a Bag into these three portions:

a. Local Host Messages
b. Local Net Messages
c. Foreign Net Messages

3--Local Net Delivery

Delivers local net and local host messages, may call on conversion program.

4--Foreign Net Router

Creation of new Message-Bags for forwarding to other MPMs, determines route.

5--Foreign Net Shipper

Activates foreign shipping channels and ships Message-Bag to foreign MPMs. Performs data compression while shipping bags.

All of these components can be thought of as independent. Of the five, the Acceptor, the Local-Net Delivery, and the Message-Bag Processor are fully self-contained and communicate with each other only through a queue, the Bag-Input Queue. The function of the Acceptor is to await incoming Message-Bags and to insert them into the Bag-Input Queue.

That queue is the input to the Message-Bag Processor component which will separate and deliver suitable portions of the Message-Bags it retrieves from the queue to one of three queues:

a. Local-Host Queue
b. Local-Net Queue
c. Foreign Net Queue

When a MPM decides to forward a message to another MPM, it must add its own identification (i.e., its ihn) to the stamp field of the command. The stamp then becomes a record of the route the message

has taken. An MPM should examine the stamp field to see if the message is in a routing loop. Some commands require the return of the stamp as a trail in the matching reply command.

All of these queues have as elements complete Message-Bags (some of which may have been portions of the original Bag).

The Local-Host and Local-Net queues serve as input to the Local-Net Delivery process. This component is responsible for delivering messages to its local host and other hosts on its local net to which it is connected. It must be capable of handling whatever error conditions the local net might return, including the ability to retransmit. It may call on conversion program to reformat the messages into a form the local protocol will accept. This will probably involve such things as copying shared information.

The other two processes are more closely coupled. The Foreign Net Router takes its input Bags from the Foreign Net Queue. From the internal information it contains, it determines which one of the MPMs to which it is connected should receive the Bag.

It then places the Bag along with the routing information into the Shippable Mail Queue. The Foreign Net Shipper retrieves it from that queue and transmits it across a channel to the intended foreign MPM.

The Foreign Net Router should be capable of receiving external input to its routing information table. This may come from the Foreign Net Shipper in the case of a channel going down, requiring a decision to either postpone delivery or to determine a new route.

The Router is responsible for maintaining sufficient topological information to determine where to forward any incoming Message-Bag. Decisions concerning the return of undeliverable Bags are made by the Router.

It should be stressed here that message delivery should be reliable. In the event that delivery is impossible, the message should be returned to the sender along with information regarding the reason for not delivering it.

Implementation Recommendations

Transaction numbers can be assigned sequentially with wrap around when the highest value is reached. This should ensure that no message with a particular transaction number from this source is in the network when another instance of this transaction number is chosen.

3.8. Interfaces

User Interface

It is assumed that the interface between the MPM and the UIP provides for passing data structures which represent the document portion of the message. In addition this interface must pass the delivery address information (which becomes the information in the mailbox field of the command). It is weakly assumed that the information is passed between the UIP and the MPM via shared files, but this is not the only possible mechanism. These two processes may be more strongly coupled (e.g., by sharing memory), or less strongly coupled (e.g., by communicating via logical channels).

Communication Interface

It is assumed here that the MPM use an underlying communication system, and TCP [20] has been taken as the model. Again, this is not intended to limit the implementation choices, other forms of interprocess communication are allowed and other types of physical interconnection are permitted. One might even use dial telephone calls to interconnect MPMs (using suitable protocols to provide reliable communication).

4. EXAMPLES & SCENARIOS

Example 1: Message Format

Suppose we want to send the following message:

```
Date: 1979-03-29-11:46-08:00
From: Jon Postel <Postel@ISIB>
Subject: Meeting Thursday
To: Dave Crocker <DCrocker@Rand-Unix>
CC: Mamie

Dave:

Please mark your calendar for our meeting Thursday at 3 pm.

--jon.
```

It will be encoded in the structured format. The following will present successive steps in the top down generation of this message.

1. message

2. (tid, command-list, document-list)

3. ((tn, ihn),
   (content, command),
   (header-list, body-list))

4. ((tn, ihn),
   (content,
   (mailbox, stamp, type, operation,
   arguments, error-list)),
   ((content, document-header),
   (content, document-body)))

5. ((37, 167772404),
   (0, (
   (IA: 167772359, NET: arpa, HOST: rand-unix,
   USER: DCrocker),
   (167772404),
   1
   DELIVER
   ((REGULAR)),
   ( ))),
   ((0, (
   Date: 1979-03-29-11:46-08:00
   From: Jon Postel <Postel@ISIB>
   Subject: Meeting Thursday

```
                To: Dave Crocker <DCrocker@Rand-Unix>
                CC: Mamie ) ),
          ( 0, ( Dave:

                Please mark your calendar for our meeting
                Thursday at 3 pm.

                --jon. ) ) ) )
```

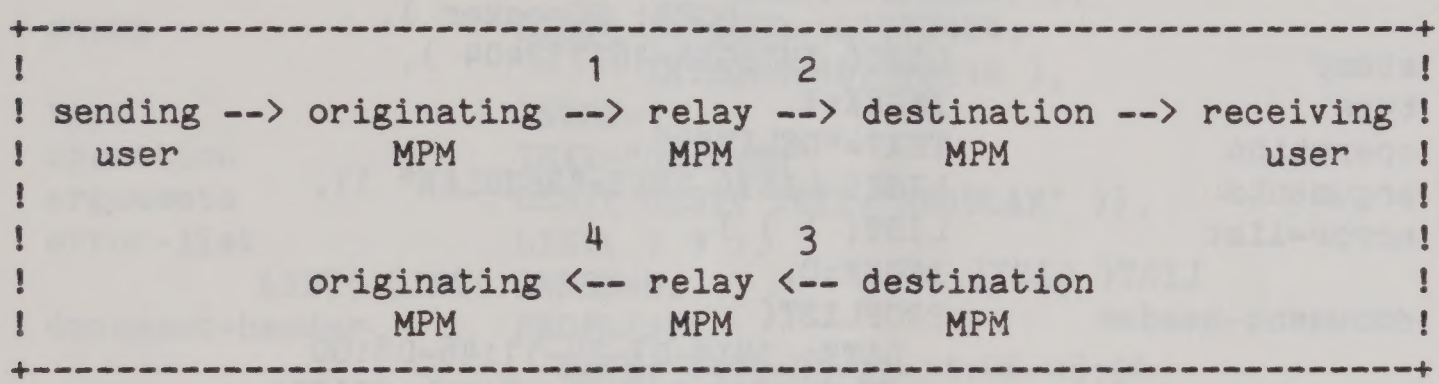
```
6.  LIST( LIST( INDEX=37, INTEGER=167772404 ),
          LIST( INDEX=0,
command         LIST( PROPLIST( IA: 167772359,
                                NET: arpa,
mailbox                         HOST: rand-unix,
                                USER: DCrocker ),
stamp                   LIST( INTEGER=167772404 ),
type                    INDEX=1
operation               TEXT="DELIVER"
arguments               LIST( LIST( TEXT="REGULAR" )),
error-list              LIST( ) ) ),
          LIST( LIST( INDEX=0,
document-header         PROPLIST(
                          DATE: 1979-03-29-11:46-08:00
                          FROM: Jon Postel <Postel@ISIB>
                          SUBJECT: Meeting Thursday
                          TO: Dave Crocker <DCrocker@Rand-Unix>
                          CC: Mamie ) ),
                    LIST( INDEX=0,
    document-body         LIST( TEXT=
                          "Dave:

                          Please mark your calendar for
                          our meeting Thursday at 3 pm.

                          --jon." ) ) ) )
```

Example 2: Delivery and Acknowledgment

The following is four views of the message of example 1 during the successive transmission from the origination MPM, through a relay MPM, to the destination MPM, and the return of the acknowledgment, through a relay MPM, to the originating MPM.



Transmission Path

Figure 6.

1. Between the originating MPM and the relay MPM.

```
      LIST( LIST( INDEX=37, INTEGER=167772404 ),
            LIST( INDEX=0,
  command           LIST( PROPLIST( IA: 167772359,
                                    NET: arpa,
  mailbox                           HOST: rand-unix,
                                    USER: DCrocker ),
  stamp                   LIST( INTEGER=167772404 ),
  type                    INDEX=1
  operation               TEXT="DELIVER"
  arguments               LIST( LIST( TEXT="REGULAR" )),
  error-list              LIST( ) ) ),
             LIST( LIST( INDEX=0,
  document-header         PROPLIST(
                            DATE: 1979-03-29-11:46-08:00
                            FROM: Jon Postel <Postel@ISIB>
                            SUBJECT: Meeting Thursday
                            TO: Dave Crocker <DCrocker@Rand-Unix>
                            CC: Mamie ) ),
                   LIST( INDEX=0,
  document-body           LIST( TEXT=
                            "Dave:

                            Please mark your calendar for
                            our meeting Thursday at 3 pm.

                            --jon." ) ) ) )
```

The originating MPM sends the message of example 1 to a relay MPM.

2. Between the relay MPM and the destination MPM.

```
      LIST( LIST( INDEX=37, INTEGER=167772404 ),
            LIST( INDEX=0,
command             LIST( PROPLIST( IA: 167772359,
                                    NET: arpa,
mailbox                             HOST: rand-unix,
                                    USER: DCrocker ),
stamp                   LIST( INTEGER=167772404,
                              INTEGER=167772246 ),
type                    INDEX=1
operation               TEXT="DELIVER"
arguments               LIST( LIST( TEXT="REGULAR" )),
error-list              LIST( ) ) ),
                LIST( LIST( INDEX=0,
document-header         PROPLIST(
                          DATE: 1979-03-29-11:46-08:00
                          FROM: Jon Postel <Postel@ISIB>
                          SUBJECT: Meeting Thursday
                          TO: Dave Crocker <DCrocker@Rand-Unix>
                          CC: Mamie ) ),
                      LIST( INDEX=0,
document-body           LIST( TEXT=
                          "Dave:

                          Please mark your calendar for
                          our meeting Thursday at 3 pm.

                          --jon." ) ) ) )
```

The relay MPM adds its ihn to the stamp, but otherwise the message is unchanged.

3. Between the destination MPM and the relay MPM.

```
     LIST( LIST( INDEX=1993, INTEGER=167772359 ),
           LIST( INDEX=0,
 command          LIST( PROPLIST( IA: 167772404,
 mailbox                          USER: *MPM* ),
 stamp                 LIST( INTEGER=167772359 ),
 type                  INDEX=2
 operation             TEXT="ACKNOWLEDGE"
 arguments             LIST( LIST( INDEX=37,
  tid                              INTEGER=167772404 ),
                            LIST( INTEGER=167772404,
  trail                            INTEGER=167772246,
                                   INTEGER=167772359 ),
  answer                    BOOLEAN=TRUE,
  reason                    LIST( TEXT="OK" ),
  how-delivered             LIST( TEXT="ACCEPT" ) ),
 error-list            LIST( INDEX=0,
                             TEXT="No Errors") ),

 document  LIST( ) )
```

The destination MPM delivers the message to the user's UIP, and composes an acknowledgment. The acknowledgment is addressed to the originating MPM. Note that the trail is the stamp of the incoming message plus the ihn of the destination MPM.

4. Between the relay MPM and the originating MPM.

```
     LIST( LIST( INDEX=1993, INTEGER=167772359 ),
           LIST( INDEX=0,
command            LIST( PROPLIST( IA: 167772404,
mailbox                            USER: *MPM* ),
stamp                    LIST( INTEGER=167772359
                               INTEGER=167772246),
type                     INDEX=2
operation                TEXT="ACKNOWLEDGE"
arguments                LIST( LIST( INDEX=37,
 tid                                 INTEGER=167772404 ),
                                LIST( INTEGER=167772404,
 trail                               INTEGER=167772246,
                                     INTEGER=167772359 ),
 answer                         BOOLEAN=TRUE,
 reason                         LIST( TEXT="OK" ),
 how-delivered                  LIST( TEXT="ACCEPT" ) ),
error-list               LIST( INDEX=0,
                               TEXT="No Errors") ),
document  LIST( ) )
```

The relay MPM adds its ihn to the stamp and forwards the acknowledgment.

GLOSSARY

1822
: BBN Report 1822, "The Specification of the Interconnection of a Host and an IMP". The specification of interface between a host and the ARPANET.

Command List
: The part of a message used by the MPMs to determine the processing action to be taken.

datagram
: A logical unit of data, in particular an internet datagram is the unit of data transfered between the internet module and a higher level module.

Destination
: The destination address, an internet header datagram protocol field.

Document List
: The part of the message created by or delivered to a user.

header
: Control information at the beginning of a message, segment, datagram, packet or block of data.

IMP
: The Interface Message Processor, the packet switch of the ARPANET.

Internet Address
: A four octet (32 bit) source or destination address consisting of a Network field and a Local Address field.

internet datagram
: The unit of data exchanged between a pair of internet modules (includes the internet header).

Local Address
: The address of a host within a network. The actual mapping of an internet local address on to the host addresses in a network is quite general, allowing for many to one mappings.

message
: The unit of information transmitted between users of message systems. As transmitted between MPMs a message consists of a Transaction Identifier, a Command List, and a Document List.

module
: An implementation, usually in software, of a protocol or other procedure.

MPM
: A Message Processing Module, the process which implements this internet message protocol.

octet
: An eight bit byte.

Rest
: The 3 octet (24 bit) local address portion of an Internet Address.

RTP
: Real Time Protocol: A host-to-host protocol for communication of time critical information.

Source
: The source address, an internet header field.

TCP
: Transmission Control Protocol: A host-to-host protocol for reliable communication in internetwork environments.

Transaction Identifier
: The unique identifier of a message.

Type of Service
: An internet datagram protocol header field which indicates the type (or quality) of service for this internet packet.

UIP
: A User Interface Program, a program which presents message data to a user and accepts message data from a user. A program which interacts with the user in the composition and examination of messages.

XNET
: A cross-net debugging protocol.

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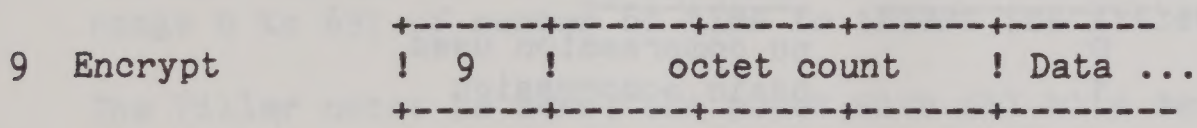
APPENDICES

A. Encryption

It would be straightforward to add the capability to have the document portion of messages either wholly or partially encrypted. The approach is to define an additional basic data element to carry encrypted data. The data within this element could be composed of other elements, but that could only be perceived after the data was decrypted.



Element code 9 (ENCRYPT) is Encrypt. The format is the one octet type code, the three octet type count, and count octets of data. Use of this element indicates that the data it contains is encrypted. The encryption scheme is yet to be decided but will probably be the Public Key Encryption technique [23] due to the capacity for coded signatures.

To process this, the user is asked for the appropriate key the first time an encryption block is seen for a particular message. The encrypted data is then decrypted. The data thus revealed will be in the form of complete data type fields. Encryption cannot occur over a partial field. The revealed data is then processed normally.

Note that there is no reason why all fields of a document could not be encrypted including all document header information such as From, Date, etc.

B. Data Compression

When message-bags are shipped between MPMs the data should be compressed according to the following scheme:

shipping-unit := compression-type message-bag

compression-type := A one octet compression type indicator.

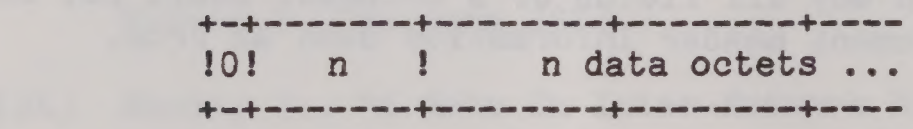
compression-type value	description
0	no compression used
1	basic compression

basic compression

This basic compression procedure is the same as that defined for use with the ARPANET FTP [8]. Three types of compression-units may be formed, sequence-units, replication-units, and filler-units. The data is formed into a series of compression-units independent of the structure or object and element boundaries.

sequence-unit

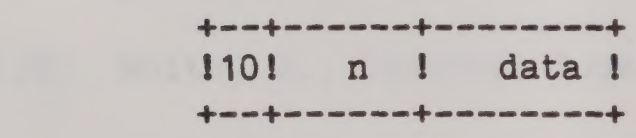
A sequence-unit is a one octet flag and count followed by that many data octets.



The flag and count octet has its high order bit zero and the remaining bits indicate the count (in the range 0 to 127) of following data octets.

replication-unit

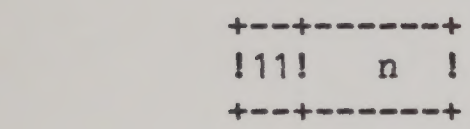
A replication-unit is a one octet flag and count followed by one data octet, which is to be replicated count times.



The flag and count octet has its high order two bits equal one-zero and the remaining six bits indicate the count (in the range 0 to 63) of number of time to replicate the data octet.

filler-unit

A filler-unit is a one octet flag and count, indicating that a filler octet is to be inserted count times.



The flag and count octet has its high order two bits equal one-one and the remaining six bits indicate the count (in the range 0 to 63) of number of time to insert the filler octet.

The filler octet is zero, the octet with all bits zero.